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# HOUSEHOLD LABOR SUPPLY IN URBAN AREAS OF BOLIVIA

Menno Pradhan and Arthur van Soest\*

**Abstract**—We analyze labor supply behavior and the choice between formal and informal sector work of the two spouses in families in urban areas of a developing country, using cross-section data from Bolivia drawn in 1989. The model generalizes the neoclassical family labor supply model. Nonmonetary returns of formal sector employment capture the fact that the choice between sectors is not exclusively based on wage differentials. Wage equations, nonmonetary returns equations, and labor supply equations are estimated jointly by smooth simulated maximum likelihood. We find substantial cross-wage elasticities of working hours of both partners, and large substitution elasticities between the two sectors.

## I. Introduction

WE analyze labor supply behavior of the two partners in two-adult families in urban areas in Bolivia, using cross-section data drawn in 1989. We distinguish four types of labor supplied by the family: husband's and wife's hours of work in the formal sector and in the informal sector. We present a static structural model, focusing on the relation between these four types of labor supply, their sensitivity to all four wages, and other family income.

One objective of this study is to analyze the sensitivity of household members' labor supply for their own and their partner's wages. In a developing country, household income is often generated by more than one member of the household. Poorer families may need more than one income to reach subsistence level. The labor supply decisions of the individual family members are likely to be correlated. For instance, if earnings of one spouse are insufficient, the partner may decide to work to generate additional family income.

The point of departure is a neoclassical family labor supply model. The family is assumed to take joint decisions regarding household consumption and labor supply of its members. It maximizes utility, determined by household consumption and leisure of family members, under a household budget restriction. This approach is used in many studies. For example, Hausman and Ruud (1984) extend the linear labor supply model for two-adult families and apply it to U.S. data. Kapteyn et al. (1990) apply this model to Dutch data. Ransom (1987) uses a quadratic utility function to analyze labor supply of two-adult households. Newman and Gertler (1994) estimate the labor supply of rural households of varying size in Peru.

We focus on urban labor markets in a developing country. In this context it is common practice to distinguish between a "formal" and an "informal" sector. During a period of

economic slump with a direct negative effect on formal sector wages, the informal sector is often seen to expand. This is referred to as the buffer function of the informal sector (Todaro (1989)). A second aim of this study is to analyze whether the choice between formal and informal sectors is driven by wage considerations only, and how sensitive it is for wage differentials.

Previous empirical studies that analyze labor supply in urban areas of a developing country include Magnac (1991), who extends the basic Roy (1951) model to analyze earnings in the formal and informal sectors in Columbia. Gindling (1991) studied wage determination in the labor market of San José, Costa Rica. Thomas (1992) provides a recent survey on both theoretical and empirical studies concerning the informal sector. Our model combines the main features of Ransom (1987) with those of Magnac (1991).

We use household survey data. Our approach implies that different utility functions would have to be used for different household types. We limit ourselves to households with one prime-age male and one prime-age female, which we refer to as two-adult households.

The organization of the paper is as follows. In section II we introduce the data set and provide descriptive statistics. In section III the model is introduced. Section IV contains information on the estimation strategy. Results are discussed in section V, and section VI concludes.

## II. Data

The research is based on data of the second round of the 1989 Bolivian household survey (Encuesta Integrada de Hogares). It uses a random sample of the urban population and is administered yearly by the Bolivian National Bureau of Statistics (Instituto Nacional de Estadística). The 1989 survey covers 7264 households in eight urban centers. 3712 households contained one prime-age male and one prime-age female, with both of them potential workers (between 19 and 65 years old, in good health, and not attending full-time education). The definition of formal and informal sectors is, following Magnac (1991), based on questions on the workers' status. Wage workers and independent professionals, such as lawyers and doctors, are classified as formal, other self-employed workers are classified as informal. Self-employed workers with household-related business assets greater than 15,000 Bolivianos (U.S.\$ 5500) are classified as formal.<sup>1</sup> Others, such as family workers or employers, are

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<sup>1</sup> Business assets include property of land, car for business use, and telephone. The idea behind this categorization is that businesses requiring high assets are not within reach for every individual. Potential entrepreneurs in the informal sector face credit constraints because their activities are hard to monitor for the lending institution.

TABLE 1.—DESCRIPTIVE STATISTICS MEANS AND SAMPLE FRACTIONS

	Male				Female			
	Formal	Informal	Not Working	Total	Formal	Informal	Not Working	Total
Basic (5)	0.22	0.36	0.31	0.31	0.10	0.44	0.34	0.43
Inter (8)	0.15	0.21	0.13	0.16	0.09	0.16	0.15	0.15
Medio (12)	0.30	0.29	0.31	0.30	0.18	0.20	0.29	0.25
Middle technical (13)	0.03	0.02	0.03	0.03	0.09	0.03	0.04	0.05
Higher technical (15)	0.03	0.02	0.03	0.02	0.04	0.01	0.02	0.02
Normal (17)	0.06	0.01	0.01	0.04	0.31	0.02	0.02	0.06
University (20)	0.17	0.06	0.15	0.14	0.15	0.02	0.04	0.05
Other	0.05	0.03	0.04	0.04	0.04	0.12	0.11	0.10
Married <sup>a</sup>	0.96	0.98	0.91	0.96	0.96	0.94	0.97	0.96
Ethnic <sup>b</sup>	0.33	0.42	0.36	0.34	0.24	0.47	0.34	0.36
Age	35.74	37.84	39.55	36.69	34.22	35.72	33.15	33.98
Wage <sup>c</sup>	2.29	2.22			2.07	1.75		
	3.21	2.72			1.89	2.36		
Hours <sup>d</sup>	52.11	53.87		47.92	36.92	45.96		17.72
Standard deviation of hours	17.09	18.01		22.43	15.98	25.83		25.70
Othinc <sup>e</sup>	7.72	5.72	37.09	9.79	10.27	7.56	10.65	9.79
Observations	1889	879	274	3042	481	787	1774	3042

Notes: (1) Sector definitions are based on worker status.

(2) Dummy variables "basic" through "university" denote highest levels of education attended. The minimum number of years required for each type is in parentheses. Vocational training is referred to as "technical." "Normal" includes teacher training for primary education. "Other" includes all other types of education.

<sup>a</sup> Married = 1 if married, 0 otherwise.

<sup>b</sup> Ethnic = 1 if mother tongue is not Spanish, 0 otherwise. It is an indicator for ethnic minorities.

<sup>c</sup> Wage = hourly wage rate in Bolivianos (Bs). At the time of the survey 1 Boliviano was about 0.37 U.S. dollar. Income taxes do not play an important role. The bulk of government revenues is collected through a consumption tax.

<sup>d</sup> Hours = working hours per week.

<sup>e</sup> Othinc = household income (Bs per week) excluding earnings. Othinc = 0 for 84.5% of all families. We did not correct othinc for savings and did not allow for endogeneity of othinc.

not classified.<sup>2</sup> 476 households were excluded because one of the partners could not be classified, 146 because one of the partners had jobs in both sectors. Finally, 48 households were excluded due to missing information on one of the necessary variables (education level, hours worked).<sup>3</sup>

The sample used for estimation thus contains 3042 families.<sup>4</sup> Table 1 contains descriptive statistics. 91% of all males are working, compared to 40% of all females. The majority of males work in the formal sector, the majority of females do not participate. Most individuals in the informal sector have little education; the higher educated dominate in the formal sector. Ethnic minorities are found more frequently in the informal sector. Average other, nonlabor, income is highest for those who do not participate. Average hourly earnings in the formal sector are slightly higher than in the informal sector.<sup>5</sup> Average hours worked are higher in the informal sector. The hourly earnings distribution of

TABLE 2.—FEMALE LABOR SUPPLY BY MALE WAGE QUINTILES

Wage Quintile, Male	Participation Rate, Female	Log Wage, Female
Not working	51.1 (3.0)	0.14 (0.07)
1 (poor)	44.7 (2.1)	-0.34 (0.06)
2	36.7 (2.1)	-0.06 (0.06)
3	41.2 (2.1)	0.22 (0.06)
4	37.3 (2.1)	0.39 (0.05)
5 (rich)	43.9 (2.1)	0.83 (0.06)

Notes: Participation rate is in percentages; log female wage is conditional upon working. Standard errors are in parentheses.

working males and females in the sample is very similar to that in the original sample of 7264 families.

Table 2 contains some prima facie evidence of intrahousehold effects of labor supply. We have calculated the average female participation rate and the average log wage of working females by wage quintile of the male. The female participation rate is highest in the lower and upper male wage brackets. Yet female wages increase with the male's wage. The high participation rate in the lower quintile could be explained by the low income earned by the male—one income is not enough to support the family. For the high male wage bracket, the own wage effect of the female seems to dominate—the high wage she can earn induces her to work.

<sup>2</sup> See Pradhan and van Soest (1995) for details on the classification and for sample statistics on an individual level.

<sup>3</sup> In principle, the likelihood could be adjusted to account for missing information in hours worked. We did not consider this worth the effort—only 10 observations would be recovered.

<sup>4</sup> For the sample of 3712 households consisting of one prime-age female and one prime-age male, average per-capita household consumption is 142.8. For the selected sample it is 137.2. This suggests that sample selectivity due to data cleaning might not be too serious. Compared to the average in the total survey, per-capita income of two-adult households is 8% lower.

<sup>5</sup> For those with one job, hourly earnings are obtained as the ratio of average earnings and average hours worked. For those with two jobs (in the same sector), a weighted mean is used. Earnings and hours worked questions in the survey are identical for the two sectors.

### III. The Model

Few individuals hold jobs in both sectors (fewer than 5%), and these are removed from the sample. Our model therefore explains sector choice and earnings and hours worked in the chosen sector, rather than hours worked in both sectors. We assume that an individual can earn a fixed hourly wage in each sector, where wages in the two sectors can be different. The simplest would then be to assume that the individual chooses the sector with the highest wage rate. This, however, is not necessarily consistent with the data. We introduce unobserved nonmonetary returns to explain why people may choose the sector yielding the lower (monetary) earnings.

The model consists of three parts. The first describes the wage rates in both sectors for both spouses, excluding nonmonetary returns. The second part consists of nonmonetary returns equations. The choice between formal and informal sectors is based on comparing wages, including nonmonetary returns. Wage rates, including nonmonetary returns, in the optimal sector are input variables for the third part of the model, the labor supply section. This part explains joint labor supply decisions of both spouses, including the decisions of whether to participate (in the optimal sector) or not. We discuss the three parts of the model separately.

#### A. Wages

The log hourly wage in both sectors (excluding nonmonetary returns) is modeled as a linear function of exogenous variables and an error term,

$$\ln w_{kj} = X_k \tau_{kj} + \eta_{kj}, \quad \eta_{kj} \sim N(0, \sigma_{kj}^2),$$

$$j = 1(\text{formal}), 2(\text{informal}), \quad (1)$$

$$k = m(\text{male}), f(\text{female}).$$

(The subscript indicating the household has been dropped.) We use four separate wage equations to describe earnings in both sectors for both sexes. The error terms are assumed to be independent of each other and of other error terms in the model.

#### B. Nonmonetary Returns and Sector Choice

Under the assumption of homogeneous preferences and free movement between sectors, everyone chooses the sector in which the wage offer is the highest. This is the assumption in the classical Roy (1951) model. In practice, however, individuals do not necessarily participate in the sector with the highest wage offer. On the one hand, demand factors may limit movement between sectors. In particular, the view that entrance into the formal sector is restricted is widely spread (Fields (1975)). On the other hand, preferences for sectors may differ across individuals. For example, apart from wages, larger freedom in the informal sector or larger job

security in the formal sector may be considered. We capture such effects under nonmonetary returns to the job. This is the monetary equivalent of all nonwage factors that influence sector participation. Magnac (1991) interprets nonmonetary returns as rationing.

We model nonmonetary returns relative to the monetary wage. Only the difference between nonmonetary returns in the two sectors is identified. We normalize nonmonetary returns in the informal sector to zero. The log of nonmonetary returns (NMR) in the formal sector is denoted by  $NMR_k$  ( $k = m$  (male),  $f$  (female)). It is assumed to be a function of individual characteristics, local labor market conditions, and an error term:

$$\ln(NMR_k + 1) = V_k \gamma_k + \mu_k,$$

$$\mu_k \sim N(0, \sigma_k^2), \quad k = m, f. \quad (2)$$

We assume that the sector choice is determined by wages, including nonmonetary returns. For the formal sector the wage is  $w_{k1}^* = (NMR_k + 1)w_{k1}$  ( $k = m, f$ ). For the informal sector, the wage  $w_{k2}$  itself enters. The preferred sector and hourly wage (including nonmonetary returns) are thus given as follows:

$$\text{If } w_{k1}^* > w_{k2}, \text{ then formal sector: } w_k^* = w_{k1}^* \quad (3)$$

$$\text{If } w_{k1}^* < w_{k2}, \text{ then informal sector: } w_k^* = w_{k2}.$$

Wages and nonmonetary returns thus determine the choice between formal and informal sectors. Whether the individual will prefer employment in the optimal sector to nonparticipation will depend on  $w_m^*$ ,  $w_f^*$ , and the labor supply part of the model.

#### C. Labor Supply

This part of the model is identical to that of Ransom (1987). A household is characterized by a quadratic direct utility function which has household consumption and leisure of both partners as arguments. The family maximizes utility subject to a household budget constraint and nonnegativity conditions on hours worked:

$$\max U(Z) = \alpha Z - \frac{1}{2} Z' \beta Z \quad (4)$$

subject to

$$w_m^* h_m + w_f^* h_f + Y = C$$

$$h_m \geq 0$$

$$h_f \geq 0$$

with

$$Z = [T - h_m, T - h_f, C]'$$

$T$  = time endowment

$h_m, h_f$  = hours worked by male and female

$C$  = family consumption

$Y$  = nonlabor income

$$\alpha = (\alpha_m, \alpha_f, \alpha_3)' \in \mathbb{R}^3, \quad \beta \in \mathbb{R}^{3 \times 3}.$$

We assume that the budget constraint is binding, i.e., utility increases with  $C$ . If neither of the two nonnegativity conditions on hours is binding, first-order conditions can be written as

$$\begin{aligned} \alpha_m^* + \alpha_3^* w_m^* - \beta_{11} h_m - \beta_{33} w_m^* (w_m^* h_m + w_f^* h_f + Y) \\ - \beta_{12} h_f + \beta_{13} (2w_m^* h_m + w_f^* h_f + Y) \\ + \beta_{23} w_m^* h_f = 0 \end{aligned} \quad (5)$$

$$\begin{aligned} \alpha_f^* + \alpha_3^* w_f^* - \beta_{22} h_f - \beta_{33} w_f^* (w_m^* h_m + w_f^* h_f + Y) \\ - \beta_{12} h_m + \beta_{23} (2w_f^* h_f + w_m^* h_m + Y) \\ + \beta_{13} w_f^* h_m = 0. \end{aligned} \quad (6)$$

Here  $\alpha_m^*$  and  $\alpha_f^*$  are functions of  $\alpha$ ,  $\beta$ , and  $T$  (cf. Ransom (1987)). The quadratic specification implies that there is no need to specify the time endowment  $T$ . Following Ransom (1987), we allow  $\alpha_m^*$  and  $\alpha_f^*$  to be functions of observed taste shifters  $Q_{ki}$  and unobserved taste shifters  $\epsilon_{ki}$  ( $k = m, f$ ), where the subscript  $i$  denotes the household (in the sequel we omit that subscript for ease of notation):

$$\alpha_k^* = Q_k \Gamma_k + \epsilon_k, \quad k = m, f, \quad \epsilon = \begin{pmatrix} \epsilon_m \\ \epsilon_f \end{pmatrix} \sim N(0, \Sigma). \quad (7)$$

If a nonnegativity constraint is binding and one spouse does not work, the corresponding first-order condition changes into an inequality condition. For given  $w_m^*$  and  $w_f^*$  this results in a simultaneous model of two tobit equations. Due to the quadratic utility function, the underlying latent model is linear.

#### D. Complete Model

The model consists of eight equations: two wage equations and one nonmonetary returns equation for each spouse, and two labor supply equations. Note that the labor supply part of the model uses wages in levels, while wage equations and nonmonetary returns are in logs, so that the model as a whole is nonlinear. Parameters to be estimated are  $\tau_{kj}$ ,  $\sigma_{kj}^2$  ( $j = 1, 2$  and  $k = m, f$ ) in equation (1),  $\gamma_k$ ,  $\sigma_k^2$  ( $k = m, f$ ) in equation (2),  $\Gamma_k$  ( $k = m, f$ ) and  $\Sigma$  in equation (7), and the  $\beta_{ij}$  ( $i, j = 1, 2, 3$ ) in equations (5) and (6). By means of normalization,  $\beta_{11}$  is set equal to 1.

The approach is an improvement on the Ransom (1987) approach in that the wage equations are incorporated and

estimated jointly with the labor supply equations. Ransom predicted wage offers for nonparticipants using a separate model, thus ignoring wage rate prediction errors. Furthermore, we distinguish between two sectors. The model also generalizes the approach of Magnac (1991). Our approach is more structural, and we do not only consider participation but also hours worked. Moreover, while Magnac considers individuals, we work at the household level and analyze intrahousehold interactions.

It should be admitted that the model is restrictive in various ways. A more general way to model sector choice would be to incorporate hours worked in both sectors separately in the utility function. Family utility would then depend on five arguments instead of three. The general solution would allow that individuals work in both sectors simultaneously, something we hardly observe in our data. Our model a priori excludes the possibility of two jobs in two different sectors. Nonmonetary returns can be seen as a specific way of transforming preferences (proportional to wages). This implies that the sector choice does not depend on hours worked.

Restrictions that seem hard to justify from an economic point of view are those imposed on the covariance matrix of the error terms. We have eight error terms and only allow for correlation between two of them (random preferences of the two spouses). Thus, for example, independence of all errors in equations (1) and (2) implies that the sector choices of the two spouses (conditional on exogenous variables) are independent. Given our estimation strategy (see below), a more general covariance structure is feasible in principle. It would, however, require a substantially larger computing effort and is thus beyond the scope of the current study.

#### IV. Estimation

Due to the model's nonlinear nature, an analytical expression for the likelihood cannot be given. Exact likelihood contributions would in many cases require numerical integration in more dimensions. Instead, we maximize an approximation of the likelihood, based on simulations of some of the errors in the wage and nonmonetary returns equations. This method is an example of (smooth) simulated maximum likelihood (SML) (cf. Boersch-Supan and Hajivassiliou (1993), for example). We describe the main idea here. Details are given in the appendix.

If both partners in a given family work in the informal sector and  $w_m^*$  and  $w_f^*$  are known, the likelihood contribution of the labor supply part of the model (conditional on wages) is identical to that in Ransom (1987). We denote it by  $L_l(h_m, h_f | w_m^*, w_f^*)$ . To keep the notation simple, we suppress the other arguments on which it depends (taste shifters, other family income).<sup>6</sup> The complete likelihood contribution is

<sup>6</sup> Note that, due to the model assumptions (including independence of errors in equations (1) and (2) from those in equation (7)),  $L_l$  depends on the chosen sector through  $w_k^*$  ( $k = m, f$ ) only.

then given by

$$L(h_m, h_f, s_m, s_f, w_m^*, w_f^*) = L_I(h_m, h_f | w_m^*, w_f^*) \times L_m(s_m, w_m^*) L_f(s_f, w_f^*). \quad (8)$$

Here  $L_m$  and  $L_f$  are the likelihood contributions of the wage and nonmonetary returns equations for male and female, and  $s_m$  and  $s_f$  are the observed sectors of male and female. Because of the linearity of this part of the model and independence of the errors, computing  $L_m$  and  $L_f$  is easy. Both are similar to Magnac's (1991) likelihood. Thus if  $w_m^*$  and  $w_f^*$  are known, the exact likelihood contribution can be used.

This is only relevant, however, if both partners work in the informal sector. If either of them does not work in the informal sector, or if the wage is not reported, the relevant wage (including nonmonetary returns) is not observed. In case of nonparticipation, this is the familiar problem in estimating structural labor supply models with unobserved wage rates (cf. discussion in MaCurdy et al. (1990)). In case of formal sector work, we observe the monetary wage, but  $w_k^*$  includes unobserved nonmonetary returns. Let us consider the case that both spouses work in the formal sector. The likelihood contribution can then be written as

$$L(h_m, h_f, s_m, w_m, w_f) = E[L_I(h_m, h_f | w_m^*, w_f^*) \times L_m(s_m, w_m^*) L_f(s_f, w_f^*)]. \quad (9)$$

The expectation is taken with respect to the unobserved errors in the nonmonetary returns equations, linking observed  $w_m$  and  $w_f$  to unobserved  $w_m^*$  and  $w_f^*$  (see appendix). The expectation cannot be computed analytically, since  $L_I$  is a complicated function of  $w_m^*$  and  $w_f^*$ . We replace it by a

TABLE 3.—ESTIMATES FOR TASTE SHIFTERS IN LABOR SUPPLY MODEL

	$\Gamma_m$	$\Gamma_f$
Constant	1.796 (0.632)	-5.257 (0.896)
Young	0.131 (0.033)	-0.094 (0.029)
Old	-0.122 (0.265)	0.098 (0.185)
Age	1.293 (0.340)	2.141 (0.444)
Age squared/100	-1.993 (0.411)	-2.527 (0.544)
$\Sigma_{kk}$ ( $k = m, f$ )	7.955 (0.309)	2.833 (0.862)
$\Sigma_{mf} = -1.859$ (0.539)		

Note: Standard errors are in parentheses.

TABLE 4.—ESTIMATES OF  $\beta_{ij}$

	Male Leisure	Female Leisure	Consumption (/10)
Male leisure	1		
Female leisure	-0.243 (0.045)	0.270 (0.046)	
Consumption (/10)	-0.181 (0.022)	-0.183 (0.026)	0.0078 (0.0014)

Note: Standard errors are in parentheses.

simulated mean,

$$L_H(h_m, h_f, s_m, s_f, w_m, w_f) = (1/H) \sum_{j=1}^H \times [L_I(h_m, h_f | w_{mj}^*, w_{fj}^*) \times L_m(s_m, w_{mj}^*) L_f(s_f, w_{fj}^*)]. \quad (10)$$

Here  $w_{mj}^*$  and  $w_{fj}^*$  ( $j = 1, \dots, H$ ) result from adding  $H$  independent draws of  $M_k$  to  $V_k \gamma_k$  in (2), and adding the sums to the observed log formal sector wages.

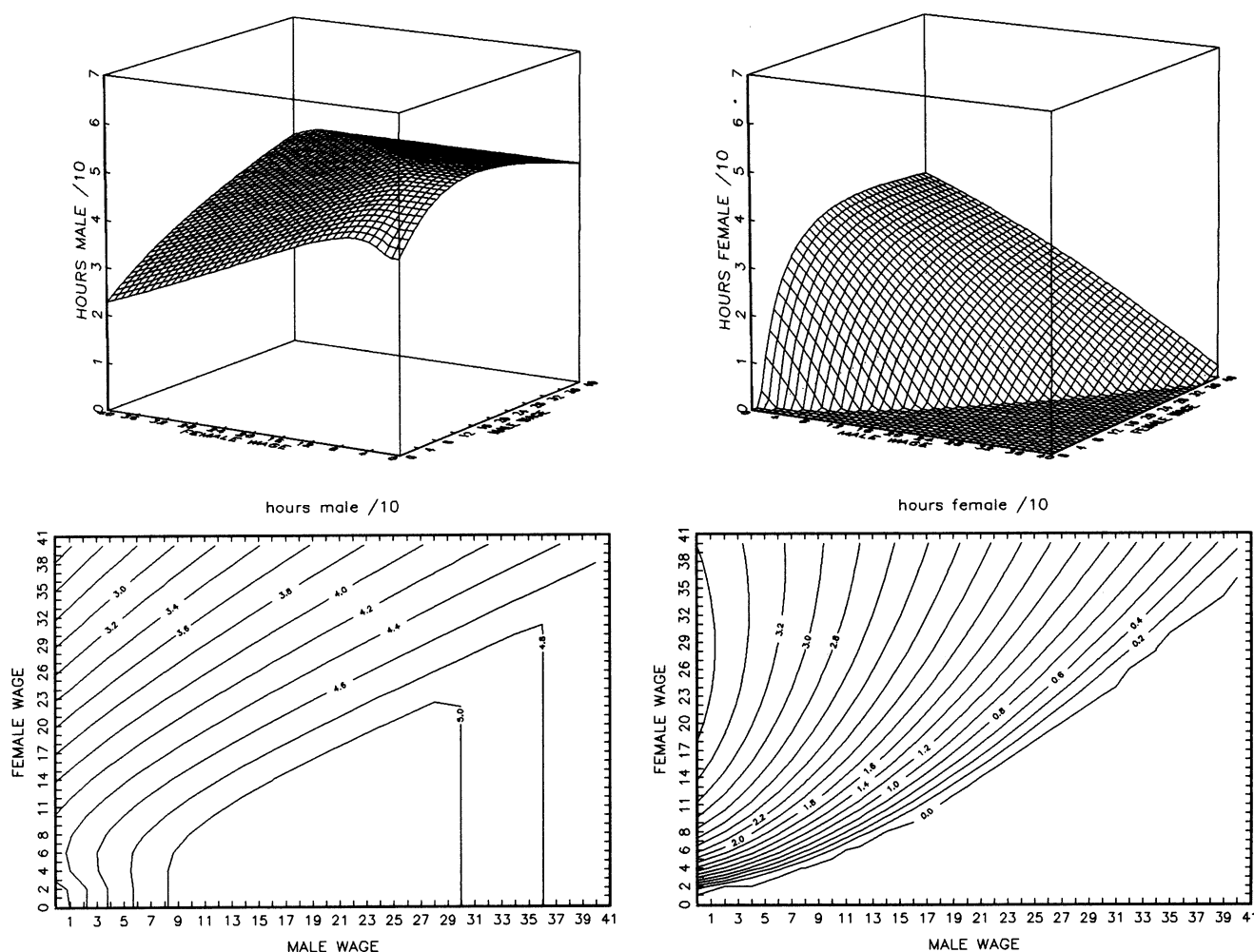
This procedure is easily generalized to other cases. For those individuals who do not participate, we draw all six errors in the wage and nonmonetary returns equations. The maximum wage offer from the two sectors is substituted in the labor supply part of the model. This type of nonlinearity was also solved through simulation by Laroque and Salanié (1989) for a disequilibrium model. The sample likelihood is approximated by replacing each likelihood contribution by its simulated approximation. The SML estimator maximizes the approximate sample likelihood.<sup>7</sup>

The estimator is consistent if  $N \rightarrow \infty$  (number of observations) and  $H \rightarrow \infty$  (number of draws per observation). Moreover, if draws for different observations are independent and  $\sqrt{N}/H \rightarrow 0$  (i.e.,  $H \rightarrow \infty$  "fast enough"), SML is asymptotically efficient and equivalent to maximum likelihood (Gourieroux and Monfort (1993)). Because the errors in the labor supply part of the model are retained and not simulated, the approximate likelihood is a continuous and differentiable function of the parameters. This makes maximization feasible and should, according to previous studies on similar models (Boersch-Supan and Hajivassiliou (1993)), lead to satisfactory results for small  $H$  already. We use  $H = 60$ .<sup>8</sup>

<sup>7</sup> In principle, simulations could be avoided, since the likelihood contribution can always be rewritten as a two-dimensional integral (over  $w_m^*$  and  $w_f^*$ ). The integral could be computed numerically. However, accurate two-dimensional integration can be quite time consuming and requires a larger programming effort. Note that, in spite of the independence assumptions, the double integral cannot be written as the product of two single integrals because of the factor  $L_I$ .

<sup>8</sup>  $H = 30$  leads to virtually identical results. Similarly, Pradhan (1993) finds, for a similar model, that increasing the number of draws further hardly changes the results.

FIGURE 1.—LABOR SUPPLY FUNCTIONS



## V. Results

We first present the estimates of the labor supply model, equations (4)–(7). The estimates of  $\Gamma_m$  and  $\Gamma_f$  in equation (7) are given in table 3. A higher value of  $\alpha_k^*$  ( $k = m, f$ ) is associated with a higher propensity to work, since  $\alpha_k^*$  decreases with  $\alpha_k$ . Exogenous variables in  $Q_k$  refer to family composition and age. The number of children (age  $\leq 18$ ) in the household (young) significantly increases the propensity to work for males and has the opposite effect for females. The number of household members older than 64 (old) is insignificant. A quadratic age pattern is significant for both males and females. The propensity to work is highest at age 33 for males and at age 42 for females. There is a significant negative correlation between the two random preference terms. This could be due to assortative matching between spouses.

The estimates for the matrix  $\beta$  are presented in table 4. All coefficients are significant. The marginal utility of leisure increases with additional leisure of the partner. Marginal utility of both partners increases with family consumption. In the first-order conditions, equations (5) and (6), we have

implicitly assumed that utility increases with family consumption. According to our results, this is the case for 2939 out of 3042 observations. The 103 remaining observations are ignored in the simulations below. Moreover, the solution of the Lagrange equations corresponds to the utility maximum if the utility function is quasiconcave. Positive definiteness of  $\beta$  is sufficient but not necessary for this. Despite the fact that the estimate of  $\beta$  is not positive definite, concavity conditions are satisfied without exception.<sup>9</sup>

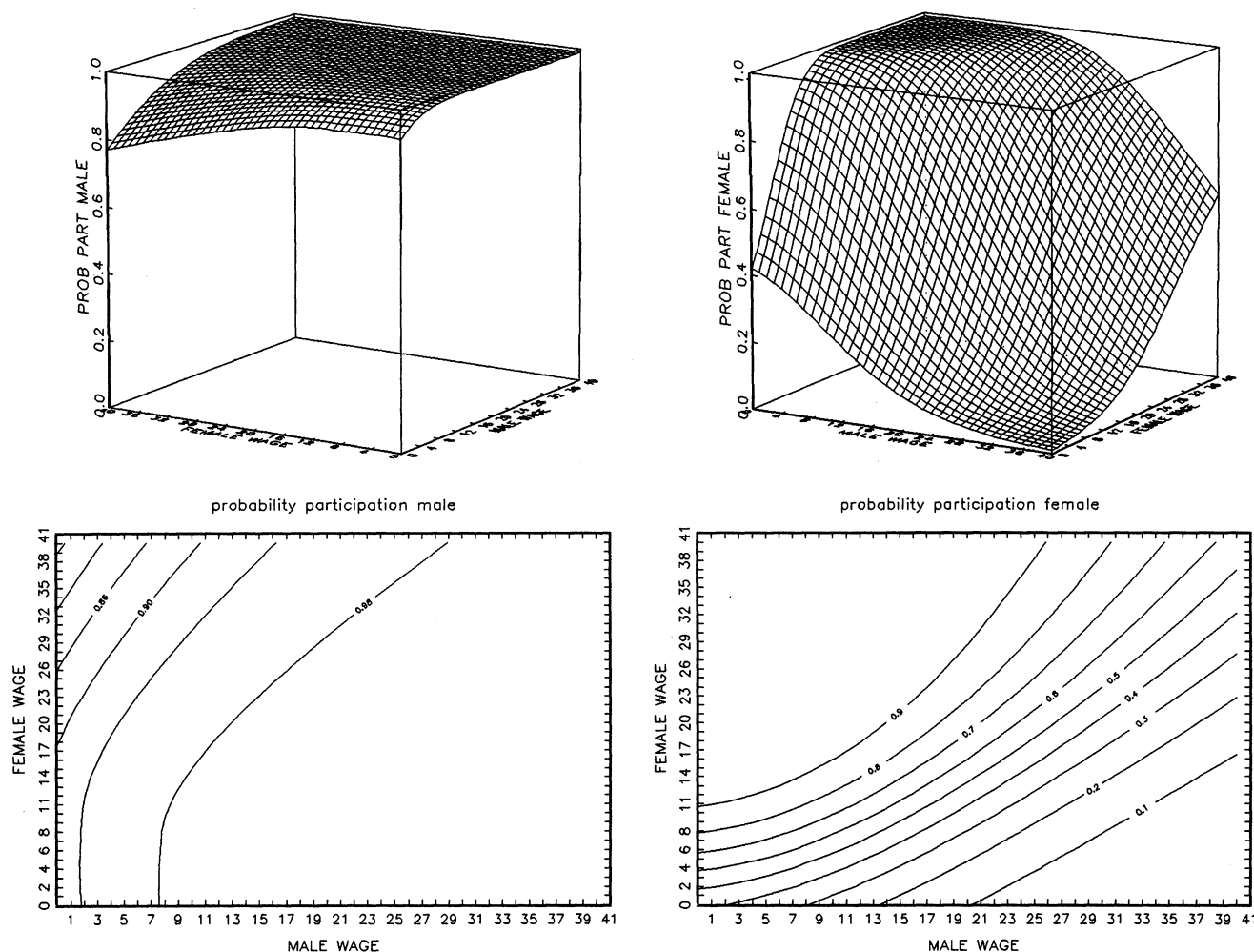
Figures 1 and 2 illustrate the shape of the labor supply curves. Family characteristics are kept at the mean predicted value. Figure 1 shows unconditional supply curves, i.e., predicted numbers of hours worked for males and females as a function of both wages (including nonmonetary returns).<sup>10</sup>  $\alpha_m^*$  and  $\alpha_f^*$  are set equal to their sample means ( $\alpha_m^* = 4.0$ ,  $\alpha_f^* = -1.4$ ), random terms in preferences are set equal to zero. Male labor supply is forward bending in most of the

<sup>9</sup> This also implies that the model is coherent, in the sense that endogenous variables are uniquely determined (cf. van Soest et al. (1993)).

<sup>10</sup> Estimated sample averages of wages (including nonmonetary returns) are 6.6 for males and 3.0 for females.



FIGURE 2.—PARTICIPATION PROBABILITIES



range of male wages, and backward bending for very high wage rates, where the income effect dominates the substitution effect. If  $w_f^*$  is low, the female does not work, and male hours depend on  $w_m^*$  only. If the female works, male hours are affected negatively by the female's wage. The wife's hours of work increase with her own wage and decrease with the husband's wage.

Figure 2 shows the probability of participation for both males and females as a function of both wages. Random preference terms are taken into account.<sup>11</sup> For females, the own wage effect on the probability of working is positive. The effect is stronger if the male wage is low. The effect of the husband's wage on the wife's participation is negative but small. For the family characteristics considered, the probability that the male participates is always higher than 0.80. For the male there is a small positive own wage effect and a negligible cross-wage effect. Only for extremely high female wages, a substantial negative cross-wage effect is found.

<sup>11</sup> This is in contrast with figure 1. Excluding random preference terms would imply that participation probabilities would be 0 or 1.

The estimates of wage and nonmonetary returns equations for both sexes are presented in table 5. In the wage equations we have included individual characteristics such as age, education level, ethnicity, and variables describing local labor market conditions such as the local unemployment rate and a measure for the size of the economically active population, a proxy for the size of the local market. The specification is similar to that in Pradhan and van Soest (1995), and so are the results. For example, returns to education are larger in the formal sector than in the informal sector. This may indicate that the formal sector requires skills obtained through the formal education system or that education is used as a screening device in the formal sector. A larger local labor market leads to a higher wage. The effect is significant for males in the formal and for females in the informal sector. The significantly negative effect of the local unemployment rate is largest in the informal sector. This can be explained by the fact that the informal sector is more competitive than the formal sector. In the formal sector, ethnic minorities are paid significantly less than others.

In the nonmonetary returns equations for the formal sector we have included the variables of the wage equations and

TABLE 5.—ESTIMATED COEFFICIENTS FOR WAGE EQUATIONS AND NONMONETARY RETURNS (NMR) EQUATIONS

	Male			Female		
	Formal	Informal	NMR	Formal	Informal	NMR
Constant	-1.169 (0.277)	0.476 (0.376)	2.283 (0.453)	-1.781 (0.569)	-0.750 (0.497)	-1.869 (0.960)
Age	0.611 (0.133)	0.240 (0.165)	0.196 (0.236)	0.630 (0.276)	0.451 (0.230)	1.007 (0.528)
Age squared	-0.645 (0.171)	-0.244 (0.199)	-0.680 (0.300)	-0.784 (0.366)	-0.485 (0.287)	-1.376 (0.708)
Inter	0.175 (0.060)	-0.049 (0.073)	-0.325 (0.105)	0.600 (0.136)	0.184 (0.098)	0.172 (0.228)
Medio	0.377 (0.051)	0.127 (0.069)	-0.068 (0.073)	0.851 (0.124)	0.188 (0.087)	0.246 (0.199)
Midtech	0.665 (0.108)	0.205 (0.179)	-0.079 (0.230)	1.197 (0.150)	0.077 (0.187)	0.961 (0.232)
Hightech	0.835 (0.116)	0.319 (0.231)	-0.114 (0.271)	1.161 (0.238)	0.736 (0.273)	1.499 (0.318)
Normal	0.611 (0.099)	-0.441 (0.173)	0.254 (0.144)	1.357 (0.131)	0.145 (0.242)	2.579 (0.190)
University	1.239 (0.059)	0.085 (0.103)	-0.086 (0.093)	1.868 (0.126)	0.427 (0.167)	1.195 (0.225)
Other	0.541 (0.089)	-0.113 (0.168)	0.481 (0.138)	0.139 (0.171)	-0.251 (0.120)	-0.575 (0.302)
Miss years	0.084 (0.014)	0.015 (0.022)	0.011 (0.024)	0.124 (0.030)	0.026 (0.026)	0.140 (0.050)
Econ act	0.154 (0.028)	0.038 (0.044)	-0.314 (0.052)	0.109 (0.052)	0.167 (0.053)	-0.067 (0.079)
Unemployed	-0.601 (0.117)	-1.242 (0.172)	-0.544 (0.189)	-0.518 (0.222)	-0.951 (0.207)	-0.367 (0.250)
Ethnic	-0.137 (0.042)	-0.069 (0.060)	-0.379 (0.073)	-0.162 (0.085)	0.012 (0.075)	-0.201 (0.115)
Young			-0.038 (0.020)			-0.071 (0.033)
Old			-0.151 (0.143)			0.254 (0.114)
$\sigma$	0.737 (0.009)	0.794 (0.018)	1.285 (0.038)	0.700 (0.023)	0.899 (0.021)	1.210 (0.055)

Notes: Education level is incorporated as follows. First, dummies are used to indicate the highest level of courses attended. Second, for those who did not complete the course, we used the deviation between the level attained and the level if completed, expressed in years ("miss years"). This deviation is zero if the course is finished and negative otherwise. "Econ act" is the number of working or searching individuals in the sample per urban center. See table 1 for other variables. Standard errors are in parentheses.

two taste shifters: the numbers of young and old persons in the family. Nonmonetary returns may result from demand-side constraints (rationing) or from individual preferences concerning sector participation. For both males and females we find that "normal" education (primary school teachers) has positive nonmonetary returns. People with this type of training prefer teaching in a primary school (in the formal sector) to informal sector work. If preferences do not depend on ethnicity, the negative coefficient on "ethnic" can be interpreted as high job search costs of ethnic minorities for formal sector jobs, or discrimination. Ethnic groups are thus discriminated against twice: formal wages are lower, and formal sector jobs are harder to find. The number of young children increases preference for informal sector jobs. This could be because of higher flexibility of when and how much

to work in the informal sector. Also, additional income could be generated in the informal sector by child labor. The hypothesis of weakly competitive markets (all parameters in the nonmonetary returns equation equal zero), as defined by Magnac (1991), is strongly rejected for both males and females.

#### A. Simulations

To see how well the model predicts the distribution of hours worked and sector participation, we present figure 3 and table 6. For all observations in the sample we have simulated wages, nonmonetary returns, and hours worked, taking one draw from the distribution of the error terms.<sup>12</sup> In figure 3 the predicted and the actual sample distributions of hours worked are shown. Actual hours distributions for males are peaked at 40 and 48 hours per week. These peaks are not fully captured by the predictions. This would require a model incorporating restrictions on hours worked, as in Dickens and Lundberg (1993). Flexibility of female hours is much higher; both actual and predicted hours are more dispersed.

In table 6 we present sector choice and participation of both spouses.<sup>13</sup> We compare actual and predicted numbers. The model underpredicts the number of nonparticipants, particularly for males. Explanations may be fixed costs of working or a lack of available part-time jobs. The ratios of formal and informal sector participation rates are predicted reasonably well.

In table 7 we present the results of some simulation exercises. The objective of the first two simulations is to examine the importance of intrahousehold effects. We first consider a 10% fall of wages for all males. This has hardly any effect on the average number of hours the male works. Participation of males slightly decreases. Labor supply of females, however, shows a stronger response: their average number of hours worked increases by 2.5%, corresponding to a cross-labor supply elasticity of  $-0.25$ . A closer look at the own labor supply response for males reveals that the low elasticity is not uniform over the sample. Males with a positive labor supply response are those who initially had a high wage. For most males with a low wage, the labor supply response to a wage decrease is negative. This corresponds with the inverted U-shape of labor supply in figure 1.

Second, we consider a 10% fall of wage rates of females. This has a very small effect on hours worked by males and females. Male hours increase and female hours decrease, but both effects are less than 1%. To get some insight in aggregate income elasticities, we also performed a simulation in which nonlabor income increased by 10% for all households. For 84% of the households this has no effect, since their nonlabor income was zero to start with. The

<sup>12</sup> Using more than one draw yields virtually identical results.

<sup>13</sup> Tables 6 through 8 are based on the 2939 observations for which utility increases with family consumption.

FIGURE 3.—HOURS DISTRIBUTIONS

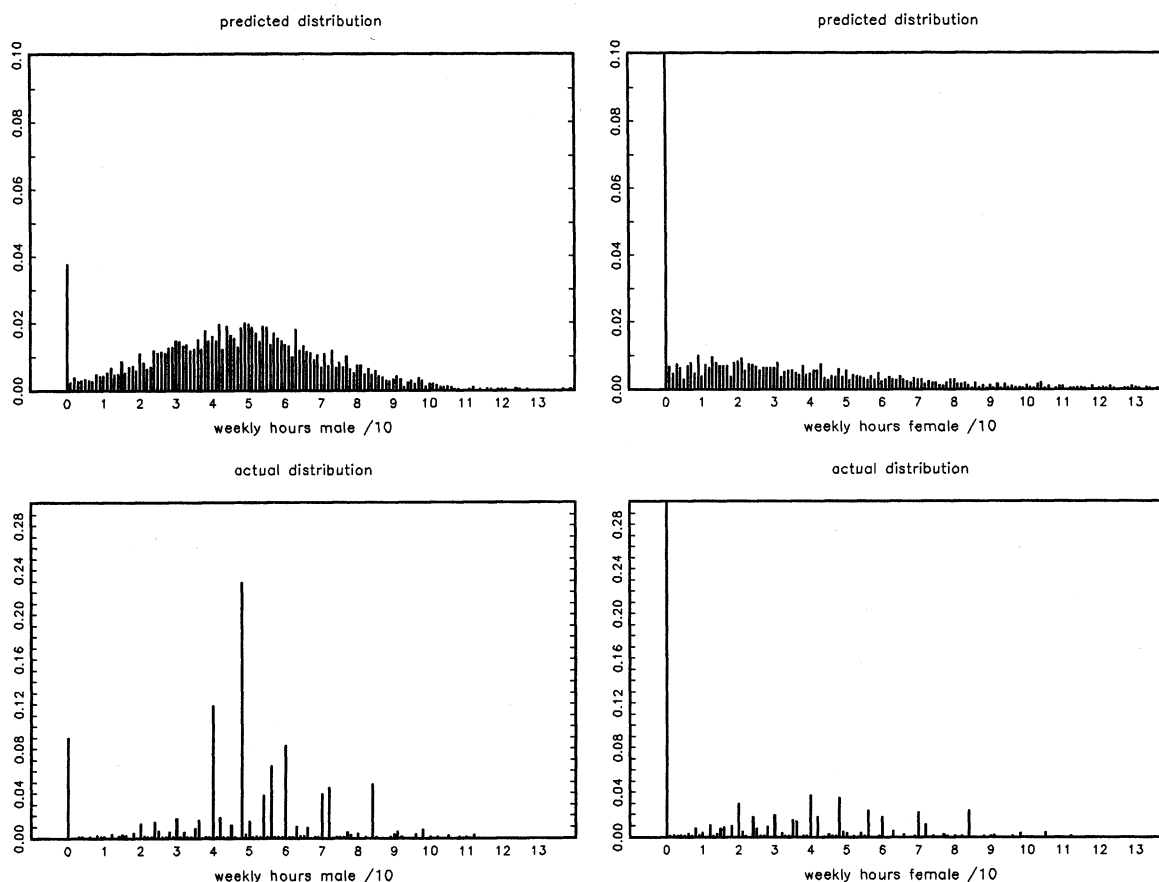


TABLE 6.—CROSS TABULATION OF PERCENT SECTOR PARTICIPATION FOR MALE AND FEMALE

Female ⇒ Male ↓	Female		Informal		Not Working		Total	
	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Formal	10.8	9.9	12.2	15.7	38.0	39.4	62.0	64.9
Informal	2.8	4.7	10.2	10.0	16.6	16.5	29.7	31.3
Not working	1.4	1.0	3.4	1.3	4.6	1.6	9.3	3.8
Total	15.0	15.6	25.8	27.0	59.2	57.4	100	100

TABLE 7.—SIMULATIONS

	Actual	Predicted Mean	Wage Male -10% Drop	Wage Female -10% Drop	Formal Wage -10% Drop
Wage offer, male		2.11 (0.04)	-0.211 (0.004)	0	-0.135 (0.005)
Wage offer, female		1.52 (0.04)	0	-0.152 (0.004)	-0.052 (0.004)
Hours, male	47.48	47.38 (0.53)	-0.033 (0.038)	0.100 (0.013)	0.081 (0.030)
Percent working	90.68	96.85 (0.22)	-0.117 (0.061)	0.060 (0.049)	-0.015 (0.058)
Hours, female	17.05	16.91 (0.70)	0.428 (0.036)	-0.136 (0.029)	0.290 (0.030)
Percent working	40.76	42.42 (0.87)	0.826 (0.188)	-0.743 (0.161)	0.433 (0.168)
Household income	124.79	137.95 (2.24)	-9.088 (0.230)	-2.913 (0.148)	-6.491 (0.267)

Notes: Sample averages and changes of sample averages. Standard errors are in parentheses, based on 400 draws from estimated asymptotic distribution of estimator of  $\beta$ . Wage and income excluding nonmonetary returns.

effects were quite small. For both males and females, hours worked decrease slightly. Income elasticities are 0.002 for males and 0.019 for females.

Finally, an objective of this study is to see how sensitive sector choice and participation are for wage changes in one sector. We consider a fall in all formal sector wages by 10% (see tables 7 and 8).<sup>14</sup> 2.1% of all males switch from formal to informal sector while the participation rate for males hardly changes. Participation of females increases by 0.4%. This is a result of two opposite effects: an increase due to reduced partner's earnings (cf. previous simulation), and a decrease due to the fall of the own (formal sector) wage. The average number of hours worked increases for both males and females. The labor supply of males increases since

<sup>14</sup> This fall could, for example, be induced by raising income taxes in the formal sector or a cut in government wages. A change in informal sector wages leads to similar conclusions.

TABLE 8.—PERCENT SECTOR PARTICIPATION RATES AFTER 10% DROP IN FORMAL SECTOR WAGES

	Male		Female	
	Before, Mean	After Drop	Before, Mean	After Drop
Formal	66.2 (0.86)	-2.06 (0.22)	15.2 (0.58)	-0.68 (0.17)
Informal	30.7 (0.83)	2.05 (0.22)	27.3 (0.81)	1.12 (0.20)
Not working	3.2 (0.22)	0.02 (0.06)	57.6 (0.87)	-0.43 (0.17)

Note: Standard errors are in parentheses.

formal sector workers are generally in the higher income brackets. The size of the informal sector increases by 5.5%. This prediction should be viewed as an upper limit, since a fall in formal sector wage offers will often be accompanied by a fall in informal sector wages.

## VI. Conclusions

We have analyzed the labor supply behavior and the choice between formal and informal sector work of the two spouses in two-adult families in urban areas of Bolivia. We have developed a static neoclassical model, combining the family labor supply model of Ransom (1987) with the model explaining sector choice and earnings of Magnac (1991). Our main empirical conclusion is that intrahousehold effects are substantial: low earnings of the husband are compensated by more working hours of the wife. Qualitatively, the elasticities we find are largely in line with the findings of Ransom (1987) for the United States. We find a smaller own wage elasticity of female labor supply than Ransom, and a larger cross-wage elasticity of female labor supply. Apart from large differences between the populations of interest, this may also be due to the model specification. Our approach allows for a more flexible wage structure than Ransom's. The significant differences between wage equations for the two sectors indicate that this is a substantial improvement.

Second, we find that lower wages in the formal sector induce more people to work in the informal sector, while the effect on nonparticipation is small. Third, we find that nonmonetary returns in the formal sector are usually positive. This implies that, on average, if the formal and informal sector wages are equal, people prefer a formal sector job. It can be explained by differences in job characteristics. This finding is different from that of Magnac (1991), who finds that nonmonetary returns are insignificant for married females in Columbia. We find larger nonmonetary returns for males than for females. For females, nonmonetary returns are particularly important for some education levels, for example, for those with teacher training. Differences in educational systems might explain part of the deviation from Magnac's findings.

Although our model captures some features of the data quite well, a simulation makes clear that it is not fully capable to reproduce the data. In particular, nonparticipation of males is underpredicted. Allowing for fixed costs of working or constraints on hours worked might help to overcome this problem. Relaxing the tight stochastic specification might also help. The quadratic specification of the utility function, together with the estimation method of smooth simulated maximum likelihood, make these extensions feasible areas of future research.

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## APPENDIX

### Simulated Likelihood Contributions

The likelihood contributions consist of three parts,  $L_f$ ,  $L_m$ , and  $L_p$ , as introduced in equation (8).  $L_f$  is the contribution of the labor supply part of

the model, for given wages  $w_m^*$  and  $w_f^*$  of males and females. The expression for  $L_f$  is given in Ransom (1987).  $L_m$  and  $L_f$  are the likelihood contributions of wage equations and nonmonetary returns for males and females, respectively. Because males and females are treated identically,  $L_m$  and  $L_f$  are similar. We first consider the  $L_m$ .

If the male works in the formal sector,  $w_m$  is observed, but  $w_m^*$  is not because of nonmonetary returns. If  $\mu_m$ , the error in the NMR equation, were known, the likelihood contribution of this section of the model would be given by

$$L_m(\mu_m) = \int_{-\infty}^{\ln(w_{m1}) + V_m\gamma_m + \mu_m - X_m\tau_{m2}} f_{m2}(\eta_{m2}) d\eta_{m2} f_{m1}(\eta_{m1}) \quad (A.1)$$

where  $f_{kj}$  denotes the (normal) probability density function (pdf) of  $\eta_{kj}$ .  $L_m(\mu_m)$  is thus easy to compute.

If the male works in the informal sector, we observe  $w_m^*$ . Nonmonetary returns in the informal sector are zero. The likelihood contribution equals

$$L_m = \int_{-\infty}^{\ln(w_{m2}) - X_m\tau_{m1} - V_m\gamma_m} g(\mu_m + \eta_{m1}) d(\mu_m + \eta_{m1}) f_{m2}(\eta_{m2}) \quad (A.2)$$

where  $g$  is the (normal) pdf of  $\mu_m + \eta_{m1}$ .

If the male does not participate, we don't know whether the informal or the formal sector wage is relevant, and we must condition on  $\eta_{m1}$ ,  $\eta_{m2}$ , and  $\mu_m$ .  $L_m$  equals 1 and vanishes. The wage that enters into  $L_m$  equals

$$w_m^*(\eta_{m1}, \eta_{m2}, \mu_m) = \exp [\max (X_m\tau_{m1} + \eta_{m1} + V_m\gamma_m + \mu_m, X_m\tau_{m2} + \eta_{m2})]. \quad (A.3)$$

$L_f$  is calculated in a similar way. The full likelihood contribution of the family is given by the expectation of  $L_f L_m L_f$  with respect to the error terms that we conditioned on. For example, if the husband works in the formal sector and the wife does not participate, the exact likelihood contribution is given by

$$L(h_m, h_f, s_m, w_m) = \int L_f(h_m, h_f, w_m^*(\mu_m), w_f^*(\eta_{f1}, \eta_{f2}, \mu_f)) \times L_m(\mu_m) f(\mu_m, \eta_{f1}, \mu_{f2}, \mu_f) d\mu_m d\eta_{f1} d\eta_{f2} d\mu_f \quad (A.4)$$

where  $f$  denotes the (normal) pdf of  $(\mu_m, \eta_{m1}, \eta_{f2}, \mu_f)$ . The four-dimensional integral in equation (A.4) cannot be computed analytically, because  $L_f$  is a complicated nonlinear function of  $w_m^*$  and  $w_f^*$ . It is replaced by the simulated mean

$$L_H(h_m, h_f, s_m, w_m) = \left( \frac{1}{H} \right) \sum_j^H [L_f(h_m, h_f, w_m^*(\mu_{mj}), w_f^*(\eta_{f1j}, \eta_{f2j}, \mu_{fj})) L_m(\mu_{mj})] \quad (A.5)$$

where  $(\mu_{mj}, \eta_{f1j}, \eta_{f2j}, \mu_{fj})$ ,  $j = 1, \dots, H$ , are independently and identically distributed draws from the distribution of  $(\mu_m, \eta_{f1}, \eta_{f2}, \mu_f)$ . Other cases are treated in a similar way. The integral to be replaced varies from six dimensional ( $h_m = h_f = 0$ ) to zero dimensional (male and female work in the informal sector).